LG, YDC 2/21/02
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Testing procedure and results for z-axis phase 0 deployment system

The majority of the testing was performed and witnessed by Leo Greiner (LG) and Yuen-dat Chan (YDC) at LBL on March 16, 2002. Verification and witnessing of repeated tests was done on March 18, 2002 with Herb Steiner as witness. Test results are shown in *italic*. All wetted materials have been radiopurity and scintillator compatibility checked.

Results Summary:

The KanLAND z-axis phase 0 deployment system mechanical and control system were tested according to the following procedure. The reproducibility and accuracy of the deployment system are within the measurement error of < 1.5 mm over a deployment distance of ~ 8 meters. The mechanical and control systems performed smoothly and without error. The system is now ready for shipment, assembly and checkout in Japan.

General function.

- Software reliability – Run software for at least 3 days. Note any crashes or irregularities.
  The software was run multiple times for sessions of up to 1 week without crashes or errors noted.
- Limit switch – Does the limit switch stop the upward return of the source? Does the shaft encoder position reset to the home (0) count? Does the source deploy downward while the limit switch is activated?
  The limit switch stops the upward return of the source. This was verified in test of 16 repetitions at LBL by LG and YDC on 3/16/02. The displayed shaft encoder position resets to the home position (0) when a separate reset function is performed manually after the source trips the limit switch and stops at the home position. This has been successfully tested on 3/16/02 and 3/18/02. The source does deploy downward (only) after tripping the limit switch as verified in test of 16 repetitions at LBL by LG and YDC on 3/16/02.
- Slip clutch – What amount of weight hanging from the source rod causes the slip clutch to slip? Does the device function correctly after the slip clutch slips?
  Weights of over 4.25 kg will cause slippage. This was set and tested by LG during setup. The device functions correctly after the slip clutch slips. This functionality was checked by LG, YDC and HS during testing.
- Overall – Is the functioning mechanically smooth? Does anything bind? Check over all deployments for cable kinking or knotting. Check for excess heat after 6 deployments of 8 meters.
  The functioning of the device is smooth and error free as witnessed in tests of 16 repetitions at LBL by LG and YDC on 3/16/02. No mechanical binding was observed in any of the tests. The cable wraps very well and there have been no observed instances or hints of cable kinking or knotting during the testing on

3/16/02 and 3/18/02 or at any other time. After 6 continuous deployments in rapid succession of ~8 meters (far longer duration of motor activity than planned for calibration runs) the heat conducted from the metal motor mounting bracket raised the temperature of the mount to approximately 50 degrees C. The motor temperature limit (where the thermal cutoff activates) is 100 degrees C.

Specific performance tests

Materials / Assembly Strength –

1. Test the strength of the spool attachment => cable => source rod attachment assembly by putting a load of 25 kg through the assembly.
2. Test the level of the noise generated by the system when in use, especially with the motor running.
   Both of these tests will be performed after the final assembly in Japan. The expected test date is 4/5/02.
3. Test the function of the slip clutch by stopping the spool by hand with the motor turning. Note slip clutch function.
   This functionality was checked by LG, YDC and HS during testing at B51 on 3/18/02. The slip clutch works as designed.

Manual control box function –

1. Deploy and retract the source via the manual control box 4 times
2. Check the functioning of the controls, note any irregularities.
   This was done as part of the tests on 3/16/02. The control box functions all performed as designed. The manual control box deployments are shown in table 1as deployments 1-5.There were no irregularities observed.

Shaft encoder accuracy and reproducibility –

1. Deploy the source via computer control to the maximum height available (at least 25')
2. Note location of source and shaft encoder count.
3. Return the source to home position.
4. Note location of source and shaft encoder count.
5. Repeat 6 times.
6. Record results.
   This was done as part of the tests on 3/16/02. The data is shown in the attached Table 1. This data was used to calculate the calibration constant for the shaft encoder to give the actual distance traversed.

Speed –

1. Measure speed of deployment
   The time required to move the source a distance of 7.6 meters was 2 minutes and 45 seconds. This indicates a rate of 1 meter every 22 seconds. The rate was independent of direction.

Shaft encoder slippage –

1. Repeat above test but coat the wire and pulley with mineral oil.

2. Record results.
   This was done as part of the tests on 3/16/02. The data is shown in the attached Table 1 with oiled deployment runs shown in ***bold****. No slippage at all was detected. Manually forcing the pulley to slip on the wire indicated that the friction between these components to still be quite adequate with the 1.5 kg. weight, even when coated in mineral oil.*

Software performance

(I) PC control:

(A) Test general protection scheme. Free from gui/user-caused crashes?
We tested the computer control system extensively on 3/16/02 and before. No gui or user induced crashes were observed.

(B) Unusual Occurrence Handling
   1) reliability of warning signals
      The manual operation mode warning sign tested OK. In-motion warning "beeping" sound tested OK.
   2) reliability of software halts/stops.
      The reliability of the software starts and halts tested OK.
   3) pc crash test
      The motor stopped after the predetermined move. OK.
   4) power off/back on test
      No auto startup. OK.
   5) Encoder reading inconsistency warning.
      This was tested by taking the wire rope off of the pulley (hence the encoder is no longer coupled to the driving system.) The Unusual Occurrence warning panel appeared after the motor was started, as it should.

(C) Local data logging
   1) motion history log file.
      A text file called C:\ZAXIS_AUTO_LOG is updated automatically every time a motion request is executed. It updated correctly during the test.
   2) overwite protection
      The history information should be appended rather than overwrote. Tested OK.

(II) Manual control
   (A) power off/back on tests
      This tested OK.
   (B) Controller software download/upload test.
      Controller software downloaded correctly from a previous test. Users are not allowed to change the firmware of the controller.

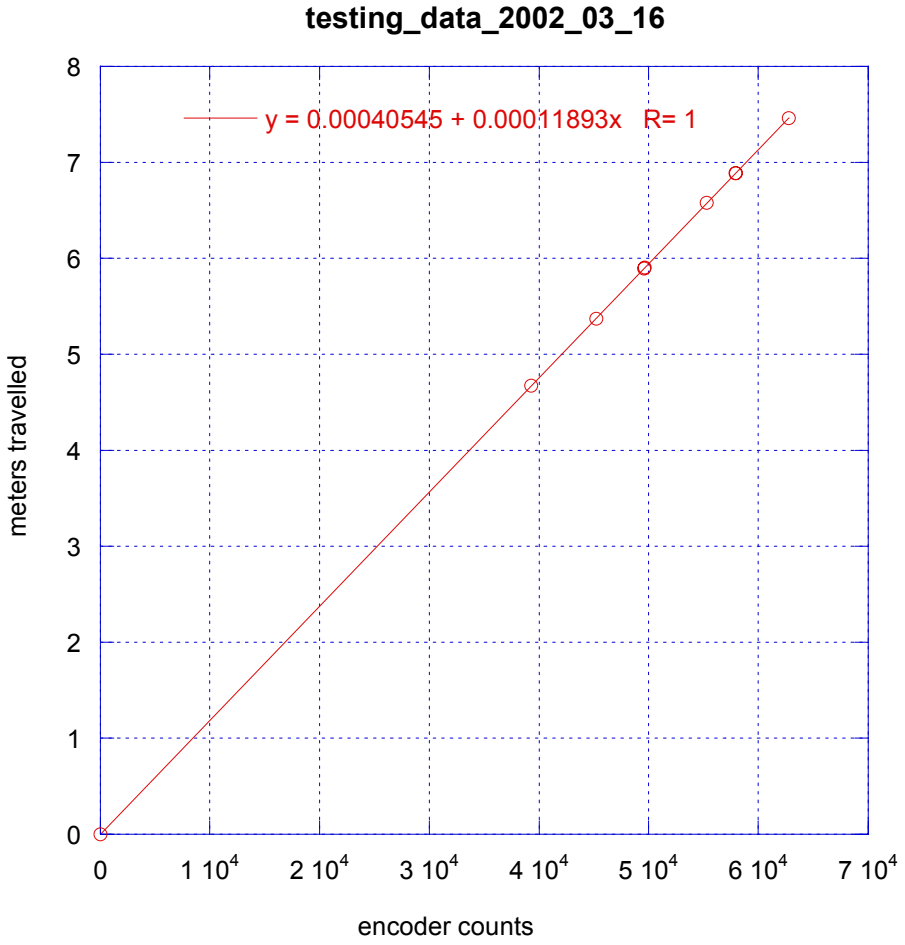
Stress test –
1. Deploy and return the source 6 times in rapid succession.

2. Check for function and heat buildup.
3. Record temperature and any abnormal functioning.
   Tested on 3/16/02. After 6 continuous deployments in rapid succession of ~8 meters (far longer duration of motor activity than planned for calibration runs) the heat conducted from the metal motor mounting bracket raised the temperature of the mount to approximately 50 degrees C. The motor temperature limit (where the thermal cutoff activates) is 100 degrees C.

Table 1

Deployment	Shaft encoder counts	Stepper motor counts	Distance in meters	Shaft encoder reading at return to home position
1	62757	5.3586e+05	7.4628	-4
2	49583	4.2269e+05	5.8976	1
3	39291	3.3408e+05	4.6736	-1
4	45200	3.8512e+05	5.3753	-1
5	55304	4.7238e+05	6.5770	0
6	57951	4.9475e+05	6.8929	3
7	**57924**	**4.9493e+05**	**6.8898**	**0**
8	**49648**	**4.2357e+05**	**5.9071**	**1**
9	**49649**	**4.2389e+05**	**5.9071**	**1**
	0.0000	0.0000	0.0000	

Bold indicates that these deployments were done with the pulley and cable coated with mineral oil.
Deployments 1-5 were done under manual control box control. Deployments 7-9 were done via computer software control.



Note: The error on the points is much smaller than the symbol used.

At ~8.4 encoder counts / mm one can see that the accumulated error measured from starting at home position (limit switch tripped) deploying 8 meters and returning to home position (travel of ~16 meters) is negligibly small. Similarly, deploying multiple times to a fixed shaft encoder count and measuring the position of the source end at each deployment gave the same deployment distance to within the measurement error (the 1/16" scale on the Starret precision tape measure.